REMARKS

Claims 1 to 15 are all the claims pending in the application, prior to the present Amendment.

The Examiner has acknowledged applicants' claim for foreign priority. The Examiner has checked box 12(a) in the Office Action summary, but has not checked boxes 1, 2 or 3. Applicants request the Examiner to check the appropriate one of these boxes.

The Examiner has provisionally rejected claim 1 on the ground of non-statutory obviousness-type double patenting as being unpatentable over claim 1 of copending application no. 10/574,573.

Applicants have amended claim 1 as set forth above to include the recitations of claims 2 and 9. Applicants have canceled claims 2 and 9, and have amended claim 3 to depend from claim 1.

Thus, claim 1 now recites that the oxides which form the grain boundary region of the magnetic layer includes at least two kinds of oxide selected from those of Y oxides, W oxides, Mg oxides, Al oxides, Zr oxides, Hf oxides, Ti oxides, Ce oxides, Si oxides, Cr oxides, Ni oxides, and Ta oxides, and recites that the magnetic layer includes a total of 0.1 to 30 mol% of the oxides which form the grain boundary region.

Claim 1 of the copending application does not disclose or suggest the use of two of these oxides, and only discloses the use of one of these oxides, namely, Si oxides.

Claim 1 of the copending application recites that "the grain boundaries contain an oxide of silicon and at least one element selected from the group consisting of Li, Na, K, Rb, Cs, Ca,

Sr, and Ba, and the ratio of a total amount of substance of Si, Li, Na, K, Rb, Cs, Ca, Sr, and Ba in the perpendicular magnetic recording layer is no less than 1 mol% and no more than 20 mol%."

Thus, only one of the 12 kinds of oxides, namely, Si oxide, of amended claim 1 of the present application is recited in the claim 1 of the copending application. Therefore, claim 1 of the copending application neither discloses nor suggests the subject matter of amended claim 1 of the present application.

In view of the above, applicants request withdrawal of this rejection.

The Examiner sets forth three separate rejections based on U.S. Patent 6,689,456 to Nakazawa et al.

Thus, claims 1-5, 7 and 11 have been rejected under 35 U.S.C. § 102(b) as anticipated by Nakazawa et al.

In addition, claims 6, 8-10, 14 and 15 have been rejected under 35 U.S.C. § 103(a) as obvious over Nakazawa et al in view of U.S. Patent Publication 2005/0227122 to Takahashi et al.

Finally, claims 12 and 13 have been rejected under 35 U.S.C. § 103(a) as obvious over Nakazawa et al and further in view of U.S. Patent Publication 2005/0227122 to Takahashi et al.

Applicants submit that Nakazawa et al and Takahashi et al do not disclose or suggest the subject matter of claim 1 as amended above and, accordingly, request withdrawal of these rejections.

Each of these rejections are based on the Examiner's assertion that Nakazawa et al disclose perpendicular magnetic recording medium comprised of a nonmagnetic underlayer and a magnetic layer having a crystal structure with a grain boundary phase comprised of two oxides. The Examiner particularly refers to column 7, lines 34-50, of Nakazawa et al.

This portion of Nakazawa et al, however, does not disclose a magnetic layer that has a grain boundary region that contains two oxides. Further, this portion of Nakazawa et al contains an obvious error. Applicants submit that one of ordinary skill in the art would not interpret this portion of Nakazawa et al to mean that the magnetic layer 3 of Nakazawa et al contains two oxides in the grain boundary.

In particular, Nakazawa et al, at column 7, lines 34-50, describe grain boundary phases 7 that contain two oxides. Grain boundary phases 7, however, are present in the inorganic compound layer 2 of Nakazawa et al, and are not present in the magnetic layer 3 of Nakazawa et al.

At column 7, line 35, Nakazawa et al state that the "particles 6 of inorganic compound layer 3 contained 93% by weight of cobalt oxide having the NaC_l type crystal structure and 7% by weight of the other oxides SiO_2 and TiO_2." Applicants submit that it is clear from the remainder of the disclosure that the inorganic compound layer of Nakazawa et al is layer 2, and not magnetic layer 3.

The disclosure at column 7, line 34 appears in Embodiment 1 of Nakazawa et al, which discloses the preparation of numerous inorganic compound layers that are numbered as No. 1 to No. 11, and which are summarized in Table 1 of Nakazawa et al.

In fact, in paragraph [0049] of the counterpart Japanese Unexamined Patent Application, First Publication No. 2001-319314 (hereafter JP '314), corresponding to U. S. Patent 6,689,456 to Nakazawa et al, discloses that "The particles 6 of No. 3 contained 93% by weight of cobalt oxide having NaCl type crystal structure and 7% by weight of the other oxides SiO_2 and TiO_2." Applicants attach a computer translation of JP '314.

The "No. 3" in JP '314 is the sample number used in Table 1 of Example 1 of JP '314, and this Table 1 of JP '314 is the same as Table 1 of Nakazawa et al. Thus, the No. 3 in JP '314 is the same as the No. 3 of Nakazawa et al. At column 7 line 34, Nakazawa et al refer to the "particle 6 of inorganic compound layer 3." Applicants submit that it is clear from the counterpart Japanese application JP '314 of Nakazawa et al that the "inorganic compound layer 3" referred to by Nakazawa et al at column 7, line 34 is in error, and refers to the inorganic compound layer of Sample No. 3 in Table 1 of Nakazawa et al.

The grain boundary phases of the magnetic layers of Nakazawa et al are referred to by the reference characters 15 or 16. Nakazawa et al, in Embodiment 4 and Table 3, disclose magnetic recording media Nos. 6 and 7 which contain a magnetic layer that is made from a Target 1 that contains Co69Cr19Pt12 and a Target 2 that contains two oxides, namely, SiO_2 and TiO_2. Nakazawa et al do not disclose that these two oxides are in the grain boundary phases of the magnetic layer.

With respect to the recitation in amended claim 1 that the grain boundary region of the magnetic layer comprises at least two kinds of oxides selected from those of Y oxides, W oxides, Mg oxides, Al oxides, Zr oxides, Hf oxides, Ti oxides, Ce oxides, Si oxides, Cr oxides, Ni

oxides and Ta oxides, which recitations have been incorporated into amended claim 1 from claim 2, the Examiner asserted that Nakazawa et al disclose multiple oxide materials used to form grain boundary regions, as disclosed at column 2, line 65 to column 3, line 11.

However, the above-mentioned portion of Nakazawa et al only discloses that "said crystal particle of the inorganic compound layer contains 65% to 98% by weight of oxide (a) and 35% to 2% by weight of oxide (b) and said grain boundary phase contains 50% to 90% of oxide (a) and 50% to 10% by weight of oxide (b)." The above mentioned portion of Nakazawa et al, thus, does not disclose multiple oxide materials in the grain boundary regions of the magnetic layer, but only discloses the composition of the inorganic compound layer.

With respect to the recitations in amended claim 1 that the magnetic layer includes a total of 0.1 to 30 mol% of the oxides which form the crystal grain boundary region, which recitations have now been incorporated into amended claim 1 from claim 9, the Examiner asserted that Nakazawa et al do not disclose the stoichiometric ratios, but disclose manipulating oxides in order to better match the intermediates layer, as set forth at column 3, lines 53-58, and that, therefore, it would be obvious to manipulate ratios in order to better match the intermediate layer.

However, applicants submit that the Examiner has not correctly understood the above-mentioned portion of Nakazawa et al. The above portion of Nakazawa et al does not disclose manipulating oxides of the magnetic layer in order to better match the intermediates layer.

Nakazawa et al disclose at column 2, lines 19-23 that "an intermediate layer can be provided between the inorganic compound layer and the magnetic layer. We discovered that we

could control the particular structure of the magnetic layer by controlling the size and distribution of the crystal particles of the intermediate layer." Thus, this portion of Nakazawa et al neither discloses "manipulating the magnetic layer in order to better match the intermediates layer," nor discloses "manipulating oxides (in grain boundary regions) of the magnetic layer." In contrast, this portion of Nakazawa et al discloses that one can control the structure of crystal particles of the intermediate layer in order to control the particular structure of the magnetic layer.

In addition, Nakazawa et al disclose, at column 4, lines 55-65 that

> it is preferable that the structure of crystal particles of the inorganic compound layer or the intermediate layer is equal or similar to the structure of the magnetic particles of the magnetic layer.
>
> The above term "similar to" means the difference between the lattice constant of the magnetic particles of magnetic layer and the lattice constant of the crystal particles of the inorganic compound layer and the intermediate layer. . . .

Since this portion of Nakazawa et al does not teach or suggest the stoichiometric ratios of the oxides in the grain boundary regions of the magnetic layer, the recitation of amended claim 1 that the magnetic layer includes a total of 0.1 to 30 mol% of the oxides which form the crystal grain boundary region is non-obvious over Nakazawa et al.

In conclusion, applicants submit that claim 1 as amended above is not anticipated by Nakazawa et al. In addition, applicants submit it is non-obvious to one skilled in the art to arrive at amended claim 1 from the teachings of Nakazawa et al.

Further, Takahashi et al do not disclose or suggest the recitations of amended claim 1.

The other claims of the present application are also novel and non-obvious over Nakazawa et al and Takahashi et al because they are directly or indirectly dependent on amended claim 1.

In addition, Nakazawa et al do not disclose or suggest the recitations of claim 3. The Examiner relies on the disclosure at column 14, lines 23-28, of Nakazawa et al to show two oxides, but this disclosure relates to an intermediate layer, and does not refer to the compositions of the grain boundary phase of the intermediate layer, but only to the metal particles of the intermediate layer.

Nakazawa et al do not contain any example where an oxide of group A of claim 3 is employed in a grain boundary region of a magnetic layer with an oxide of group B.

In view of the above, applicants submit that Nakazawa et al and Takahashi et al do not disclose or suggest the subject matter of the present claims and, accordingly, request withdrawal of this rejection.

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

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WASHINGTON OFFICE
23373
CUSTOMER NUMBER

Date: August 13, 2008

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-319314

(43)Date of publication of application : 16.11.2001

(51)Int.Cl.

G11B 5/65
C23C 14/06
C23C 14/34
G11B 5/738
G11B 5/851
H01F 10/16
H01F 10/26

(21)Application number : 2000-370140

(22)Date of filing : 05.12.2000

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(30)Priority

Priority number : 2000058029 Priority date : 29.02.2000 Priority country : JP

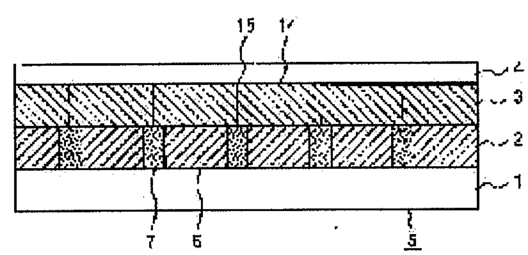
(54) MAGNETIC RECORDING MEDIUM, ITS MANUFACTURING METHOD AND MAGNETIC RECORDER USING THE MEDIUM

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a magnetic recording medium for high density recording.

SOLUTION: In the magnetic recording medium 5, an inorganic compound film 2 being a seed layer, a magnetic film 3 on which information is recorded and a protective film 4 are laminated on a substrata 1. The inorganic compound film 2 has cylindrical crystalline particles 6 and amorphous grain boundary phases 7 partitioning the particles 6. In the magnetic film 3, magnetic particles 14 are arranged and epitaxially grow on the inorganic compound film 2, so that the particle size and the standard deviation of the inorganic compound film 2 are reflected on the magnetic particles 14 of the magnetic film 3.

図 1



CLAIMS

[Claim(s)]
[Claim 1]A magnetic recording medium which has a substrate and two or more films laminated on this board characterized by comprising the following and with which said two or more films have a magnetic film in which information is recorded.
They are the particles of a crystalline substance between said substrate and said magnetic film.
A noncrystalline grain boundary phase which encloses these particles.

[Claim 2]A magnetic recording medium which has a substrate and two or more films laminated on this board characterized by comprising the following and with which said two or more films have a magnetic film in which information is recorded.
They are the particles of a crystalline substance between said substrate and said magnetic film.
A noncrystalline grain boundary phase which encloses these particles.

[Claim 3]In a magnetic recording medium which has two or more films laminated on a substrate and this board and with which said two or more films have a magnetic film in which information is recorded, The 1st constituent which an inorganic compound film which has a noncrystalline grain boundary phase which encloses particles and these particles of a crystalline substance is provided between said substrate and said magnetic film, and said inorganic compound film becomes from an oxide of a crystal structure of a NaCl type or a spinel type, the [of the periodic table] -- a magnetic recording medium, wherein it is constituted by the 2nd constituent that consists of an oxide, a nitride, or a boride of an element of I-V fellows, both said particle and said grain boundary phase contain the 1st constituent and the 2nd constituent and many 1st constituent is contained in said particle rather than said grain boundary phase.
[Claim 4]An oxide in which a 35-2wt% implication and said grain boundary phase are the 1st constituent about an oxide, a nitride, or a boride which is 65 - 98wt% and said 2nd constituent about an oxide in which said particle is the 1st constituent 50 - 90wt%, an oxide, a nitride, or a boride which is the 2nd constituent -- 50 - 10wt% -- the included magnetic recording medium according to claim 3.
[Claim 5]The magnetic recording medium according to claim 3 whose oxide of a NaCl type crystal structure of said 1st constituent is cobalt oxide (CoO), iron oxide (Fe_2O_3), magnesium oxide, manganese oxide, titanium oxide, copper oxide, or nickel oxide.
[Claim 6]The magnetic recording medium according to claim 3 whose oxides of a spinel type crystal structure of said 1st constituent are cobalt oxide (Co_3O_4) and iron oxide (Fe_3O_4).
[Claim 7]The magnetic recording medium according to claim 3 whose width of a grain boundary phase the minor axis/major axis of said 25% or less of mean particle diameter and said particle of mean particle diameter of said particle is [standard deviation (sigma) of 4-15 nm and particle diameter] 0.7-1.0, and is 0.1-2 nm.
[Claim 8]The magnetic recording medium according to claim 3 which is an alloy in which said magnetic film contains Co.
[Claim 9]The magnetic recording medium according to claim 3 with which said magnetic film has a noncrystalline grain boundary phase surrounding a magnetic particle and this magnetic particle of a crystalline substance.

[Claim 10]said grain boundary phase -- the [of the periodic table] -- the magnetic recording medium according to claim 3 containing an oxide, a nitride, or a boride of an element of I-V fellows.
[Claim 11]The magnetic recording medium according to claim 3 whose standard deviation (sigma) of 4-15 nm and particle diameter of this interlayer an interlayer is provided between said inorganic compound film and said magnetic film, and mean particle diameter of this interlayer particle is said 25% or less of mean particle diameter including interlayer particles of a crystalline substance.
[Claim 12]The magnetic recording medium comprising according to claim 11:
Said interlayer is said interlayer particle of a crystalline substance.
A noncrystalline grain boundary phase surrounding these interlayer particles.

[Claim 13]In a process of a magnetic recording medium which has a magnetic film in which two or more films laminated on a substrate and a film of this plurality record information and with which an inorganic compound film was provided between said substrate and said magnetic film, the [1st target / that was constituted from an oxide which has a crystal structure of a NaCl type or a spinel type /, and periodic table] -- a process of a magnetic recording medium carrying out the weld slag of the 2nd target constituted from at least one sort of I-V fellows' oxide, a nitride, and boride simultaneously, and forming an inorganic compound film.
[Claim 14]In a process of a magnetic recording medium which has a magnetic film in which two or more films laminated on a substrate and a film of this plurality record information and with which an inorganic compound film was provided between said substrate and said magnetic film, the [oxide / which has a crystal structure of a NaCl type or a spinel type /, and periodic table] -- a process of a magnetic recording medium carrying out the weld slag of the target which mixed a compound which consists of at least one sort of I-V fellows' oxide, a nitride, and boride, and forming an inorganic compound film.
[Claim 15]In a process of a magnetic recording medium which has a magnetic film in which two or more films laminated on a substrate and a film of this plurality record information and with which an inorganic compound film was provided between said substrate and said magnetic film, the [Cr, Ta, at least one sort of element / of Nb /, 1st target / that consists of Co and Pt /, and periodic table] -- a process of a magnetic recording medium carrying out the weld slag of the 2nd target that consists of at least one sort of I-V fellows' oxide, a nitride, and boride simultaneously, and forming a magnetic film.
[Claim 16]In a process of a magnetic recording medium which has a magnetic film in which two or more films laminated on a substrate and a film of this plurality record information and with which an inorganic compound film was provided between said substrate and said magnetic film, the [Cr, Ta, at least one sort of elements of Nb, Co and Pt, and / periodic table] -- a process of a magnetic recording medium carrying out the weld slag of the target which consists of a mixture with at least one sort of compounds of I-V fellows' oxide, a nitride, and boride, and forming a magnetic film.
[Claim 17]A magnetic recording medium using the magnetic recording medium according to claim 1, 2, or 3.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to high performance, a highly reliable magnetic recording medium and process, and the magnetic recording medium that used it.
[0002]
[Description of the Prior Art]JP,10-177712,A is the 1st foundation layer that consists of Ta and B on a glass substrate, the 2nd foundation layer that uses Cr as the main ingredients, and a magnetic layer the laminated magnetic recording medium, and the 1st foundation layer, The role which adjusts the grain size of the 2nd foundation layer and a magnetic layer is played, and it is indicated that it is satisfied with the form which reflects the detailed crystal of the 1st foundation layer as it is of high coercive force and both the characteristics of a low noise since the 2nd foundation layer and a magnetic layer are formed.
[0003]JP,6-259743,A is the magnetic recording medium which laminated the 2nd foundation layer that has a NaCl type crystal structure on a nonmagnetic substrate, the 1st foundation layer with body-centered cubic structure, and a magnetic film with hexagonal-closest-packing structure, and it is indicated that the crystal orientation of a magnetic film improves.
[0004]JP,7-311929,A is a magnetic recording medium in which the magnetic thin film was formed on the NiP ground film, and is separated by the grain boundary part in which the crystal grain child who constitutes a magnetic thin film contains a non-ferromagnetism nonmetallic phase.
Having high holding force and the low medium noise characteristic is indicated.

[0005]JP,11-66533,A among Cr, Pt, Ta, nickel, Ti, Ag, Cu, aluminum, Au, W, Mo, Nb, V, Zr, and Zn One sort of metal, Or the magnetic film has the structure separated by the grain boundary phase which many magnetic particles become from the same composing element as a magnetic particle with the magnetic recording medium in which the magnetic thin film was formed on the nonmagnetic foundation layer of two or more sorts of alloys. Excelling in magnetic properties, such as noise figure and coercive force, is indicated.

[0006]
[Problem(s) to be Solved by the Invention]However, in the aforementioned conventional technology, the control of distribution of the magnetic particle size of a magnetic film and crystal grain child size which constitutes a magnetic disk medium has a limit, and microscopic particles and a coarse particle lived together in the magnetic film. When recording information on such a magnetic film, the detailed magnetic particle might be influenced by the leakage field from the surrounding coarse particle, or big magnetic particles might act mutually, and the noise might occur. Stable record cannot be performed, if such a noise occurs when performing super-high-density record exceeding 20 Gb(s)/inch^2.
[0007]The purpose of this invention is to provide the magnetic recording medium which is stabilized and can perform high density recording, and its process.
[0008]It is in offer of the magnetic recording medium using the above-mentioned magnetic recording medium.
[0009]

[Means for Solving the Problem]If persons from a book grow up a magnetic film on an inorganic compound film which consists of crystalline particles and a noncrystalline grain boundary phase which encloses crystalline particles, Particle diameter and particle size distribution (if it puts in another way uniformity of particle diameter) of crystalline particles of an inorganic compound film found out being reflected in particle diameter and particle size distribution of a magnetic particle of a magnetic film.
[0010]And making small particle size distribution of crystalline particles of an inorganic compound film, i.e., by controlling crystalline particles of an inorganic compound film to detailed uniform particle sizes, a magnetic particle whose particle diameter is uniform and detailed was arranged regularly, and found out that a magnetic film which is stabilized and can perform high density recording could be obtained.
[0011]When a magnetic film consisted of a sludge (grain boundary phase) which deposited in a grain boundary of a crystalline magnetic particle and a magnetic particle, it found out that a magnetic particle of a magnetic film became it is more detailed and uniform [particle diameter].
[0012]By providing an interlayer between an inorganic compound film and a magnetic film, and controlling particle diameter and particle size distribution of crystalline particles of an interlayer, When a particulate structure of a magnetic film being controllable and an interlayer consisted of a sludge (grain boundary phase) which deposited in a grain boundary of crystalline particles and crystalline particles, especially a crystal grain child of a magnetic film found out that particle diameter became it is more detailed and uniform. The gist of this invention is as follows.
[0013][1]In a magnetic recording medium which has two or more films laminated on a substrate and this board and with which said two or more films have a magnetic film in which information is recorded, An inorganic compound film which has a noncrystalline grain boundary phase which encloses particles and these particles of a crystalline substance is provided between said substrate and said magnetic film, Said magnetic film has the mean particle diameter of said magnetic particle in 4–15 nm and a magnetic recording medium whose standard deviation (sigma) of particle diameter is said 25% or less of mean particle diameter including a magnetic particle of a crystalline substance.
[0014][2]Said magnetic film is in said magnetic recording medium which has a noncrystalline grain boundary phase which encloses a magnetic particle and this magnetic particle of a crystalline substance.
[0015][3]The 1st constituent which said inorganic compound film becomes from an oxide of a crystal structure of a NaCl type or a spinel type, the [of the periodic table] -- it is constituted by the 2nd constituent that consists of an oxide, a nitride, or a boride of an element of I–V fellows, and both said particle and said grain boundary phase contain the 1st constituent and the 2nd constituent, and are in said magnetic recording medium with which many 1st constituent is contained in said particle rather than said grain boundary phase.
[0016]As an inorganic compound film suitable for a magnetic recording medium of this invention, (a) the [1st constituent / that forms an oxide with a crystal structure of a NaCl type or a spinel type /, and (b) periodic table] -- it is an inorganic compound film containing at least one sort of the 2nd constituent chosen from I–V fellows' oxide, a nitride, and boride.
[0017]Especially as an oxide with a NaCl type crystal structure, at least one sort chosen from cobalt oxide (CoO), iron oxide (Fe_2O_3), magnesium oxide, manganese oxide, titanium oxide, copper oxide, or nickel oxide is good.
[0018]As an oxide with a spinel type crystal structure, cobalt oxide (Co_3O_4) and iron oxide (Fe_3O_4) are good.
[0019]Crystalline particles of an inorganic compound film are (a):(b) =65 - 98wt%:35 - 2wt%, and a grain boundary phase is (a):(b) =50 - 90wt%:50 - 10wt%, and is good for a crystal grain child and a grain boundary phase to use a thing containing (a) and (b). At this time, (a) always exists in crystalline particles of an inorganic compound film mostly from a grain boundary phase, particle diameter is [standard deviation (sigma) of 4–15 nm and particle diameter] 25% or less of mean particle diameter, and, as for width of a grain boundary phase, a minor axis/major axis is set to 0.1–2 nm in 0.7–1.0.
[0020]Co is made into a subject and a ferromagnetic which consists of an alloy containing at least one sort of elements of Pt and Cr, Ta, and Nb is used for a magnetic film formed on an inorganic compound film. This ferromagnetic has the structure where at least one sort of elements of Cr, Ta, and Nb deposit in a grain boundary of a crystal grain child who makes Co a subject, and a crystal grain child.
[0021]Particle diameter and particle size distribution of a magnetic particle of a magnetic film become almost the

same as a thing of an inorganic compound film reflecting a particulate structure of an inorganic compound film. Therefore, a magnetic particle is detailed and a magnetic film of uniform particle sizes is obtained.
[0022]a grain boundary of a magnetic particle -- the [periodic table] -- at least one sort of oxide [of I-V fellows], nitride, and boride ** may deposit. In this case, more reflecting a particulate structure of an inorganic compound film, a path is 4-15 nm, ranges of a minor axis/major axis are 0.7-1.0, and, as for particle diameter and particle size distribution of a magnetic particle of a magnetic film, standard deviation (sigma) of a path becomes 25% or less of mean particle diameter, as for a magnetic particle of a magnetic film.
[0023]Particle diameter and particle size distribution of a magnetic particle of a magnetic film reflect a particulate structure of an inorganic compound film more as a difference of a grating constant of a magnetic particle of a magnetic film and a grating constant of particles of an inorganic compound film is less than **10%.
[0024]A metal membrane of a Cr system is used for an interlayer formed between an inorganic compound film and a magnetic film. As for particle diameter and particle size distribution of metal particles of an interlayer, particle diameter and particle size distribution of a magnetic particle of a magnetic film reflect a particulate structure of metal particles of an interlayer reflecting a particulate structure of an inorganic compound film. That is, particle diameter and particle size distribution of a magnetic particle of a magnetic film become almost the same as a thing of an inorganic compound film, a magnetic particle is detailed and a magnetic film of uniform particle sizes is obtained.
[0025]an interlayer -- a grain boundary of metal particles of a Cr system -- the [periodic table] -- at least one sort of I-V fellows' oxide, a nitride, and boride may deposit. In this case, particle diameter and particle size distribution of a magnetic particle of a magnetic film reflect a particulate structure of an inorganic compound film more.
[0026]
[Embodiment of the Invention][Process] The process of the inorganic compound film of this invention is explained. In order to form an inorganic compound film on a substrate, (A) target (B) which consists of an oxide with a NaCl type crystal structure or a spinel type crystal structure the [periodic table] -- whether weld slag is simultaneously performed using two targets of the target which consists of at least one sort of I-V fellows' oxide, a nitride, and boride. Weld slag is performed using the mixed target which mixed (B) with (A).
[0027]The target which makes Co a subject and consists of at least one sort of Pt and Cr, Ta, and Nb in order to form a magnetic film on an inorganic compound film, the [periodic table] -- weld slag is carried out using the mixed target which carried out the weld slag of the target which consists of at least one sort of I-V fellows' oxide, a nitride, and boride simultaneously, or mixed such raw materials. At this time, it is good to adjust the surface ratio or the mixture ratio of a target so that it may become Co, Pt and Cr, Ta, and at least one-sort 35-2wt% chosen from the inside of the oxide of the periodic table Ith - V fellows, a nitride, and boride to 65 - 98wt% at least one sort of Nb.
[0028]If weld slag is performed, on the crystalline particles of an inorganic compound film, the magnetic particle of a magnetic film grows epitaxially, a magnetic particle will be detailed and the magnetic film of uniform particle sizes will be obtained.
[0029]the [target / which consists of Cr system metal in order to form the interlayer of Cr system metal on an inorganic compound film /, and periodic table] -- weld slag is carried out using the mixed target which carried out the weld slag of the target which consists of at least one sort of I-V fellows' oxide, a nitride, and boride simultaneously, or mixed such raw materials.
[0030]receiving 65 - 98wt% of Cr system metal at this time -- the [periodic table] -- it is good to adjust the surface ratio or the mixture ratio of a target so that it may become 35 - 2wt% about at least one sort of I-V fellows' oxide, a nitride, and boride.
[0031]If weld slag is performed, on the crystalline particles of an inorganic compound film, the crystal grain child of an interlayer grows epitaxially, a crystal grain child will be detailed and the interlayer of uniform particle sizes will be obtained. If the weld slag of the magnetic film is carried out as mentioned above on this interlayer, on the crystalline particles of an interlayer, the crystal grain child of the magnetic film of an interlayer grows epitaxially, a crystal grain child will be detailed and the magnetic film of uniform particle sizes will be obtained.
[0032]In order to grow up a magnetic particle smoothly, it is preferred that it is a structure that the crystal

structure of the crystal grain child of an inorganic compound film or an interlayer is the same as that of the structure of the magnetic particle which constitutes a magnetic film, or similar.
[0033]Less than **5% of resemblance is desirable here, in order to say that the difference of the grating constant of the crystal grain child of an inorganic compound film and an interlayer to the grating constant of the magnetic particle which constitutes a magnetic film is less than **10% and to perform crystal growth smoothly more.
[0034]Since the magnetic particle of a magnetic film is detailed, and serves as uniform particle sizes, a noise, heat fluctuation, and heat demagnetization can be reduced and a flux reversal unit can be made smaller by the above, high density recording can be performed.
[0035]For example, in the path of the magnetic particle of a magnetic film, 4-15 nm, and a minor axis/major axis in 0.7-1.0, The standard deviation (sigma) of particle diameter becomes 25% or less of mean particle diameter, and, in coercive force, a flux reversal unit can record by 3000 or more Oe by the density more than 100 nm or less and 20 Gb/inch^2.
[0036]The flux reversal unit can assume the minimum unit of reversal to be one magnetic particle of a magnetic film, and it can opt for record or elimination by observation according [whether to be equivalent to a ****** case at the magnetic particle of the magnetic film for how many pieces and] to a magnetic force microscope (MFM) etc.
[0037][Example 1] The type section figure of the magnetic recording medium in this example is shown in drawing 1. The magnetic recording medium 5 laminates the inorganic compound film 2 which is a seed layer, the magnetic film 3 in which information is recorded, and the protective film 4 on the substrate 1. The inorganic compound film 2 is pillar-shaped, the noncrystalline grain boundary phase 7 which separates the particles 6 of a crystalline substance and the particles 6 is comprised, the magnetic particle 14 arranges the magnetic film 3, and it is constituted. In this invention, the boundary of particles and particles is called a grain boundary, and especially when the noncrystalline substance deposits in the grain boundary and it has width, this is called grain boundary phase 7. The magnetic film 3 of drawing 1 has the grain boundary 15 between the magnetic particle 14 and the magnetic particle 14.
[0038]The glass substrate of 2.5 inch diameters was used as the substrate 1. The inorganic compound film 2 is formed in 30-nm thickness of the simultaneous sputtering technique using the cobalt oxide (CoO) sintering target and the target which mixed and sintered silicon oxide (SiO_2) and titanium oxide (TiO_2) to 2:1 by the mole ratio.
[0039]Pure Ar was used for the discharge gas at the time of weld slag, and, as for discharge-gas-pressure power, 2mTorr and injection high-frequency power set the 100-1000W/100mmphi, SiO_2, and TiO_2 side to 100 - 1000W/100mmphi for the cobalt oxide side.
[0040]As for the thickness of the inorganic compound film 2, 5-50 nm is good. In thickness, in less than 5 nm, an inorganic compound film does not fully show the characteristic of an inorganic compound film under the influence of the surface structure of a substrate. Since the characteristic of an inorganic compound film is fully shown when thickness is set to 5-50 nm, it is thickness sufficient as a ground film of a magnetic recording medium.
[0041]The presentation of an inorganic compound film and the crystallinity of particles from which it was obtained when a target and supplied power are changed into Table 1 and it carries out to it by a simultaneous sputtering technique are shown.
[0042]
[Table 1]

表 1

NO.	ターゲット及び投入電力(W)		無機化合物膜組成(wt%)		無機化合物膜			結晶性	備考
	CoO	SiO2-TiO2	結晶粒	結晶粒界	平均粒子径(nm)	標準偏差/平均粒子径X100 (%)	粒子短径/粒子長径 平均値		
1	100	100	CoO:85 SiO_2+TiO_2:15	CoO:80 SiO_2+TiO_2:20	8.3	14.2	0.90	○	-
2	200	100	CoO:88 SiO_2+TiO_2:12	CoO:78 SiO_2+TiO_2:22	8.6	12.3	0.92	○	-
3	300	100	CoO:93 SiO_2+TiO_2:7	CoO:75 SiO_2+TiO_2:25	9	11.2	0.93	○	-
4	500	100	CoO:95 SiO_2+TiO_2:5	CoO:73 SiO_2+TiO_2:27	9.2	13.2	0.92	○	-
5	700	100	CoO:98 SiO_2+TiO_2:2	CoO:83 SiO_2+TiO_2:17	14.2	17.5	0.91	○	-
6	1000	100	CoO:99.5 SiO_2+TiO_2:0.5	CoO:90 SiO_2+TiO_2:10	18.6	25.6	0.65	○	比較例
7	200	400	CoO:80 SiO_2+TiO_2:20	CoO:53 SiO_2+TiO_2:47	8.1	12.8	0.89	○	-
8	200	800	CoO:78 SiO_2+TiO_2:22	CoO:50 SiO_2+TiO_2:50	7.2	18.6	0.88	○	-
9	200	1000	CoO:65 SiO_2+TiO_2:35	CoO:50 SiO_2+TiO_2:50	6.2	21.2	0.89	○	-
10	170	1000	CoO:63 SiO_2+TiO_2:37	CoO:45 SiO_2+TiO_2:55	-	-	-	×	比較例
11	300	0	CoO:100	-	20.3	26.1	0.60	○	比較例

[0043]The particles 6 in which any inorganic compound film contains cobalt oxide were distributed, and the particles 6 were oxides which have a NaCl type crystal structure. Although No.1-5, and 7-9 had the grain boundary phase 7 in the grain boundary, No.6 and 11 did not have the grain boundary phase 7. No.10 had the bad crystallinity of particles and distinction of particles and a grain boundary was difficult for it.

[0044]Crystallinity is good among the particles 6 of the inorganic compound film of No.1 - 11 except No.10, and the value of mean particle diameter of 15 nm or less, and standard deviation (sigma) / particle diameter x100 was 25% or less except No.6 and 11. As mentioned above, since crystallinity was bad, particles and a grain boundary

could not distinguish No.10 clearly, and it cannot be evaluated.
[0045]Like No.6, and 10 and 11, if a SiO_2+TiO_2 ingredient separates from 35 - 2wt% of the range 65 - 98wt%, a CoO ingredient the presentation of the portion of the particles 6, The crystallinity of the particles 6 does not fall, or the standard deviation (sigma) of particle diameter becomes large, and the characteristic as an inorganic compound film is not obtained.
[0046]The picture which observed the surface of No.3 with the transmission electron microscope (TEM) is shown in drawing 2. The particles 6 whose mean particle diameter is 9 nm had arranged regularly. As a result of carrying out TEM observation similarly about inorganic compound films other than No.3, the interval of the particles 6, i.e., the width of the grain boundary 7, was 0.1-2 nm except the comparative example.
[0047]As a path of the particles 6, the area of about 300 particles of a TEM observation photograph like drawing 2 was measured, and the average value of the diameter when circle approximation of each area is carried out was calculated. Since the lattice image was observed by the particles 6, the particles 6 were crystalline substances, and since a lattice image was not checked by the grain boundary phase 7, it turned out that the grain boundary phase 7 is noncrystalline.
[0048]The presentation of the particles 6 and the grain boundary phase 7 was measured by EDX (energy dispersion type characteristic-X-ray analysis apparatus) of FE-TEM (field emission type TEM). About 5 nm and the grain boundary phase 7 extracted the beam diameter to about 0.5 nm, and the particles 6 measured the beam diameter.
[0049]The cobalt oxide in which the particles 6 of No.3 have a NaCl type crystal structure was 93wt%, and SiO_2+TiO_2 of others was 7wt%. CoO was [the remainders of the grain boundary phase 7] SiO_2 and TiO_2 75wt%. As a result of analyzing similarly about other samples, except the comparative example, 65 - 98Wt% of the particle portion had CoO in 50 - 90wt% of the range, the grain boundary phase portion had CoO in it, and the remainders were SiO_2 and TiO_2. When the particle size distribution of the particles 6 was searched for, standard deviation (sigma) / mean-particle-diameter x100 were 25% or less except No.6, 10, and 11, and the path was uniform.
[0050]Next, Co69Cr19Pt12 film (atomic %) of 12-nm thickness was formed as the magnetic film 3 by the sputtering technique on the inorganic compound film 2 of No.1 of Table 1 - 11. The Co-Cr-Pt alloy was used for the target at the time of weld slag, and pure Ar was used for discharge gas. Discharge-gas-pressure power is 3mTorr, and injection DC power is 300W/100mmphi.
[0051]Subsequently, the carbon (C) film of 5 nm of thickness was formed as the protective film 4 on the magnetic film 3. As for the conditions at the time of weld slag, discharge gas is [Ar and the discharge-gas-pressure power of 5mTorr and injection DC power] 800W/100mmphi. Although Ar was used for discharge gas in this example, the gas containing nitrogen may be used and the protective film 4 elaborates in this case.
[0052]When the surface and the section of the magnetic film 3 were observed with the electron microscope, the magnetic film 3 formed on the inorganic compound film 2 of Table 1 was growing epitaxially mostly except No.9, and the particles 6 of the inorganic compound film 2 and the magnetic particle 14 of the magnetic film 3 were the almost same sizes.
[0053]When the particle size distribution of the magnetic particle 14 was searched for, standard deviation (sigma) / mean-particle-diameter x100 were 25% or less except No.6, 10, and 11, and the path was uniform. This is because the particle diameter of the inorganic compound film 2 and a standard deviation gestalt are reflected in the magnetic particle 14 of the magnetic film 3.
[0054]As a result of measuring the magnetic properties of these magnetic films 3, coercive force except No.6, 10, and 11 3.0 - 3.8kOe, Coercive force square-shaped ratio S* which is an index of the square shape nature of the hysteresis in a M-H loop (: called hysteresis loop curve drawn when the magnetization M is measured impressing the magnetic field H to a ferromagnetic material) is 0.75-0.88, and had good magnetic properties. This has a small path of the magnetic particle 14 of the magnetic film 3, and is considered because it is uniform. On the other hand, the coercive force of the magnetic film of No.6, and 10 and 11 was 2 - 2.5Oe.
[0055]About the magnetic film provided on No.6 of Table 1, and the inorganic compound film of 10 and 11, the crystallinity of the particles of an inorganic compound film cut low as mentioned above, and it was large [the standard deviation of the particle diameter] etc., and standard deviation became large and the particle diameter of

the magnetic film was also inferior in magnetic properties.
[0056]Next, after applying lubricant to the surface of the protective film 4, the magnetic recording medium 5 was built into the magnetic recorder and reproducing device, and recording reproduction characteristics were evaluated. Drawing 3 is a perspective view showing the outline of a magnetic recorder and reproducing device.
[0057]A magnetic recorder and reproducing device has the actuator 8 which rotates the magnetic recording medium 5 and the magnetic recording medium 5, and the actuator 9 which drives the magnetic head 10.
[0058]The magnetic head 10 has a playback head and a recording head, and the recording head has an upper magnetic core, a lower magnetic core, and a gap film. Here, gap length is 0.15 micrometer using the soft magnetism film which has the high saturation magnetic flux density of 2.1T in the gap film of a recording head. The magnetic head which has giant magneto-resistance was used for the playback head.
[0059]The distance of the recording medium opposite surface of the magnetic head 10 and the magnetic film of the magnetic recording medium 5 is 20 nm. The signal equivalent to 20 Gb(s)/inch^2 was recorded on the magnetic recording medium 5, and S/N was evaluated. In the magnetic film 3 formed in inorganic compound films 2 other than No.6 of Table 1, 10, and 11, a reproducing output of 27-36 dB was obtained. On the other hand, in the magnetic film 3 formed in No.6 of Table 1, and the inorganic compound film 2 of 10 and 11, it was a reproducing output of 17-19 dB.
[0060]Here, when the flux reversal unit of the magnetic film was measured with the magnetic force microscope (MFM), in the magnetic film 3 formed in inorganic compound films 2 other than No.6 of Table 1, 10, and 11, the magnetic particle 14 about 4-5 pieces is a flux reversal unit, and it turned out that a flux reversal unit is small enough.
[0061]The width of the zigzag pattern which exists in the magnetization transition region of the track of the magnetic recording medium 5 measured with the magnetic force microscope (MFM) was also below the gap length of 0.1 micrometer and a recording head, and was remarkably small. The demagnetization by heat fluctuation or heat was not generated, either.
[0062]Since the path of the magnetic particle 14 of the magnetic film 3 is uniform, this originates in the magnetic interaction of magnetic particle 14 comrades having been reduced. Although the width of a zigzag pattern does not necessarily need to be below gap length over the track perimeter, it is an ideal that it is below gap length over the perimeter. At this time, the noise of a magnetic recording medium can be reduced remarkably.
[0063]In the magnetic recorder and reproducing device of this example, distance between the part and track with which the width of the zigzag pattern became smaller than before can be made small, and high density recording exceeding 20 Gb/inch^2 can be performed.
[0064]Although the glass substrate was used as the substrate 1 in this example, it is also possible to use aluminum, an aluminum alloy board, or the substrate made of a synthetic resin, and board size can also be changed. In order to reform the surface of a substrate, layers, such as NiP and CoCrZr, may be formed.
[0065]What makes Co a subject as a magnetic particle ingredient of a magnetic film, and contains Cr, Ta, one sort of elements of Nb and Pt, or other elements is used, and things are made.
[0066][Example 2] In this example, the inorganic compound film 2 of drawing 1 was formed using the target shown in No.1 of Table 2 - 10. The target 1 is a sintering target chosen from NiO, FeO, MgO, TiO, MnO, Co_3O_4, Fe_3O_4, or these mixtures. The target 2 is a melting target of soda lime (Na_2O-SiO_2-CaO system) glass.
[0067]
[Table 2]

表 2

NO.	ターゲット及び投入電力(W)		無機化合物膜組成(wt%)		無機化合物膜		磁性膜		備考
	ターゲット1	ターゲット2	結晶粒	結晶粒界	平均粒子径(nm)	標準偏差/平均粒子径X100(%)	平均粒子径(nm)	標準偏差/平均粒子径X100(%)	
1	NiO 300W	–	NiO:100	–	23	25.3	21	29	比較例
2	NiO 300W	ソーダライムガラス 100W	NiO:88 ガラス成分:12	NiO:78 ガラス成分:22	12.3	16.1	12.2	16.1	-
3	FeO 300W	ソーダライムガラス 100W	FeO:83 ガラス成分:17	FeO:73 ガラス成分:27	11.5	16.3	11.7	15.9	-
4	FeO＋CoO 300W	ソーダライムガラス 100W	CoO+FeO:85 ガラス成分:15	CoO+FeO:75 ガラス成分:25	10.5	17.4	10.3	18	-
5	MgO 300W	ソーダライムガラス 100W	MgO:87 ガラス成分:13	MgO:80 ガラス成分:20	12.4	10.6	11.7	13.2	-
6	TiO 300W	ソーダライムガラス 100W	TiO:89 ガラス成分:11	TiO:69 ガラス成分:31	13.2	9.2	11.2	16.9	-
7	MnO 300W	ソーダライムガラス 100W	MnO:91 ガラス成分:9	MnO:81 ガラス成分:19	11.5	20.1	14.2	13.9	-
8	CoO＋NiO＋TiO 300W	ソーダライムガラス 100W	CoO+NiO+TiO:89 ガラス成分:11	CoO+NiO+TiO:79 ガラス成分:21	13.2	12.8	12.9	14.4	-
9	Co_3O_4 300W	ソーダライムガラス 100W	Co_3O_4:82 ガラス成分:18	Co_3O_4:72 ガラス成分:28	6.5	15	7.2	17	-
10	Fe_3O_4 300W	ソーダライムガラス 100W	Fe_3O_4:85 ガラス成分:15	Fe_3O_4:75 ガラス成分:25	8.3	16.5	8.6	17.6	-

[0068]If the surface of the inorganic compound film 2 is observed with an electron microscope, the oxide in which the inorganic compound film 2 of No.1 – 8 has a NaCl type crystal structure, and the crystal grain child 6 in whom No.9 – 10 contain the oxide of a spinel type are distributed.

[0069]The standard deviation (sigma) of distribution of 6.5–13.2 nm, and the minor axis/major axis of particles of 0.7–1.0, and particle diameter also had the particle diameter of the particles 6 as small as 9.2 to 20.1% of mean particle diameter, and No.2 – 10 had uniform particle diameter. No.1, mean particle diameter is 23 nm and the standard deviation (sigma) of distribution of particle diameter also exceeds 25% of mean particle diameter.

[0070]Although the inorganic compound film of No.2 - 10 had the grain boundary phase 7 to which the noncrystalline oxide deposited in the grain boundary of the particles 6, a clear grain boundary phase was not observed by No.1.
[0071]When the magnetic film 3 was formed on the inorganic compound film 2 of Table 2, the magnetic particle 14 of the magnetic film 3 of No.2 - 10 became a thing reflecting the particle diameter of the inorganic compound film 2, and a standard deviation gestalt.
[0072]However, it was not reflected in the magnetic film of No.1, but the particle diameter of the magnetic particle became that in which the standard deviation (sigma) of distribution of particle diameter also exceeds 25% of mean particle diameter at not less than 15 nm. Therefore, in order to perform high density recording exceeding 20 Gb/inch^2, the inorganic compound film of No.2 - 10 is preferred.
[0073]As mentioned above, the magnetic recording medium in which high density recording is possible can be formed by using the inorganic compound film which serves as the crystal grain child 6 containing the oxide which has a NaCl type or a spinel type crystal structure from a noncrystalline grain boundary phase.
[0074][Example 3] In this example, on the substrate 1 of drawing 1, a cobalt oxide (CoO) target, The inorganic compound film 2 of 30-nm thickness was formed in the soda lime system glass which uses SiO_2-Na_2O-CaO as a basic component by the simultaneous sputtering technique using the target which added Si_3N_4, TiN, Fe_2B, or CoB.

[0075]Pure Ar was used for the discharge gas at the time of weld slag, and, as for discharge-gas-pressure power, 2mTorr and injection high-frequency power set the target side of 300W and soda lime system glass to 200W for the cobalt oxide side.
[0076]The substrate was heated at 300 ** during membrane formation. When the surface of the inorganic compound film was observed by TEM, as for mean particle diameter, it turned out that the grain boundary phase with 9.8-12.5 nm, and a minor axis/major axis amorphous a crystal grain child and around [of a crystal grain] 0.7-1.0 exists. Particles were crystallized and distribution (sigma) of the particle diameter of these particles was 11.9 to 20.1% of mean particle diameter.
[0077]The ingredient of SiO_2, Na_2O and CaO, and added Si_3N_4, TiN, Fe_2B or CoB was contained in the grain boundary phase. The thickness of the grain boundary phase was 0.5-1.0 nm. A grain boundary phase can be thickened by adding Si_3N_4, TiN, Fe_2B, or CoB at a target.
[0078][Example 4] In this example, magnetic-recording-medium No.1 as shown in Table 3 - 7 were created using the substrate 1 which formed the inorganic compound film 2 on the same conditions as No.3 of Example 1.
[0079]
[Table 3]

表　3

NO.	中間膜用ターゲット ターゲット1	中間膜用ターゲット ターゲット2	中間膜 平均粒子径 (nm)	中間膜 標準偏差/平均粒子径X100 (%)	中間膜 格子定数 (Å)	磁性膜用ターゲット ターゲット1	磁性膜用ターゲット ターゲット2	磁性膜 平均粒子径 (nm)	磁性膜 標準偏差/平均粒子径X100 (%)	備考
1	Cr100(Cr:100at%) 300W	—	10.5	20.1	2.9244	Co69Cr19Pt12(Co:69at%, Cr:19at%,Pt:12at%) 300W	—	10.5	20.6	図4(a)
2	Cr90Ti10(Cr:90at%, Ti:10at%) 300W	—	12.3	18.1	2.9606	Co69Cr19Pt12(Co:69at%, Cr:19at%,Pt:12at%) 300W	—	10.3	19.5	
3	Cr80Ti20(Cr:80at%, Ti:20at%) 300W	—	11.5	17.9	2.9964	Co69Cr19Pt12(Co:69at%, Cr:19at%,Pt:12at%) 300W	—	11.5	18.3	
4	Cr70Ti30(Cr:70at%, Ti:30at%) 300W	—	11.2	17.3	3.0297	Co69Cr19Pt12(Co:69at%, Cr:19at%,Pt:12at%) 300W	—	10.8	18.2	
5	Cr90Ti10(Cr:90at%, Ti:10at%) 300W	SiO_2+TiO_2 ($SiO_2:TiO_2$=1:1) 100W	10.5	14.9	—	Co69Cr19Pt12(Co:69at%, Cr:19at%,Pt:12at%) 300W	—	10.3	14.6	図4(b)
6	Cr90Ti10(Cr:90at%, Ti:10at%) 300W	SiO_2+TiO_2 ($SiO_2:TiO_2$=1:1) 100W	10.5	14.9	—	Co69Cr19Pt12(Co:69at%, Cr:19at%,Pt:12at%) 300W	SiO_2+TiO_2 ($SiO_2:TiO_2$=1:1) 100W	10.5	13.4	図4(c)
7	中間膜を形成せずに、磁性膜を直接無機化合物膜上に形成する。					Co69Cr19Pt12(Co:69at%, Cr:19at%,Pt:12at%) 300W	SiO_2+TiO_2 ($SiO_2:TiO_2$=1:1) 100W	10.8	15.4	図4(d)

[0080]The magnetic recording medium of No.1 - 4 formed the interlayer 4 which changed the composition ratio of Cr and Ti on the inorganic compound film 2, and formed the magnetic film 3 on the interlayer 4. The type section figure of the magnetic recording medium of No.1 is shown in drawing 4 (a).
[0081]Forming an interlayer by a sputtering technique using a Cr-Ti alloy target, the thickness is 10 nm. Using

pure Ar for the discharge gas at the time of weld slag, discharge-gas-pressure power is 3mTorr, and injection DC power is 800W/100mmphi.
[0082]Forming a magnetic film by a sputtering technique using a Co-Cr-Pt alloy target, the thickness is 12 nm. Using pure Ar for the discharge gas at the time of weld slag, discharge-gas-pressure power is 3mTorr, and injection DC power is 800W/100mmphi.
[0083]As shown in Table 3, the interlayer 13 of the magnetic recording medium of No.1 - 4 showed good mean particle diameter and particle size distribution reflecting the particle diameter of the inorganic compound film 2, and its distribution. The magnetic film 3 also showed the good diameter of an average magnetic particle and particle size distribution reflecting the particle diameter of the interlayer 13, and its distribution.
[0084]The interlayer particles 17 have arranged the interlayer 13 shown in drawing 4 (a), and the grain boundary 18 is among interlayer particles.
[0085]If Ti concentration is adjusted so that the grating constant of the interlayer 13 can be controlled by Ti concentration and the grating constant of the interlayer 13 may become a value between the grating constant of an inorganic compound film, and the grating constant of a magnetic film, An inorganic compound film -> interlayer -> magnetic film and each film can be grown up ease and certainly.
[0086]The magnetic particle 14 has arranged the magnetic film 3 shown in drawing 4 (a), and the grain boundary 15 is among magnetic particles.
[0087]The magnetic recording medium of No.5 formed the interlayer 13 which consists of the interlayer particles 17 of a crystalline substance, and the amorphous grain boundary phase 19 on the inorganic compound film 2, and formed the magnetic film 3 on the interlayer 13 (drawing 4 (b)).
[0088]The interlayer 13 formed by performing weld slag simultaneously using the alloy target of Cr90Ti10 used by interlayer formation of the magnetic recording medium of No.2, and the target which mixed and sintered silicon oxide and titanium oxide to 1:1 by the mole ratio.
[0089]The magnetic film 3 was formed like the magnetic film of the magnetic recording medium of No.1 - 4. The magnetic film 3 of the magnetic recording medium of No.5 had good magnetic particle diameter distribution compared with the magnetic film 3 of the magnetic recording medium of No.1 - 4.
[0090]The magnetic recording medium of No.6 formed the interlayer 13 like the magnetic recording medium of No.5, and formed the magnetic film 3 which consists of the magnetic particle 14 of a crystalline substance, and the amorphous grain boundary phase 16 on the interlayer 4. The magnetic particle 14 has arranged the magnetic film 3 shown in drawing 4 (c), and the grain boundary phase 16 is among magnetic particles.
[0091]The magnetic film 3 was formed by the simultaneous sputtering technique using the Co-Cr-Pt alloy target used by magnetic film formation of No.1 - 4, and the target which mixed and sintered silicon oxide and titanium oxide to 1:1 by the mole ratio. The magnetic film 3 of the magnetic recording medium of No.6 had good magnetic particle diameter distribution compared with the magnetic film 3 of the magnetic recording medium of No.1 - 4.
[0092]The magnetic film 3 of the magnetic recording medium of No.7 formed directly the magnetic film 3 which consists of a magnetic particle of a crystalline substance, and an amorphous grain boundary phase on the inorganic compound film 2, without providing an interlayer.
[0093]The magnetic particle 14 has arranged the magnetic film 3 shown in drawing 4 (d), and the grain boundary phase 16 is between magnetic particle 14 comrades. The magnetic film 3 was formed like the magnetic film of the magnetic recording medium of No.6. The magnetic film 3 of the magnetic recording medium of No.7 had good magnetic particle diameter distribution compared with the magnetic film 3 of the magnetic recording medium of No.1 - 4.
[0094]As a result of observing the surface and the section of each film of No.1 - 7 by TEM, which interlayer 13 and magnetic film 3 of the magnetic recording medium had grown to be epitaxial on the inorganic compound film 2. [of a magnetic recording medium] However, magnetic particle diameter distribution had the better direction at the time of forming the magnetic film 3 which has the magnetic particle 14 and the grain boundary phase 16 like No.6 and 7.
[0095]By this example, in order to improve the compatibility of the inorganic compound film 2 and the magnetic film 3, the charge of Cr-Ti system alloy was shown for the validity of the interlayer 13 in the example, but an effect also with same alloy system that added Ti, V, Mo, Mn, B, W, etc. to Cr is acquired.

[0096]By formation of an inorganic compound film, the particle diameter of the interlayer formed on it and its distribution control can be performed good. The particle diameter of an interlayer and its distribution control can be performed good by making an interlayer formation particle component and a grain boundary phase forming component live together also in an interlayer.
[0097]That is, the particle diameter of a magnetic film and its distribution control can be further performed good by being able to perform the particle diameter of the magnetic film formed on it, and its distribution control good, and making a magnetic particle ingredient and a grain boundary phase forming component live together also in a magnetic film by formation of an inorganic compound film and an interlayer.
[0098][Example 5] In this example, the magnetic disk shown in No.1 of Table 4 - 12 was manufactured.
[0099]In order to form the inorganic compound film of the magnetic disk shown in No.1 - 12, the target was produced as follows.
[0100]Na_2O-SiO_2-CaO system glass or the mixture (the mole ratio of SiO_2 and TiO_2 is 1:1) of SiO_2 of a special grade chemical and TiO_2 was blended with mean particle diameter 2.3 and 3.2-micrometer cobalt oxide at a rate shown in Table 4. After adding ethyl alcohol to these compounds and making it a mixture with uniform slurry form, it dried and corned with the spray dryer. Pressing of this granulation thing was carried out, and hotpress sintering was carried out and it was considered as the target.
[0101]The 30-nm-thick inorganic compound film was formed by the RF-sputtering method using each target. The crystallinity of each inorganic compound film, mean particle diameter and standard deviation/mean particle diameter, and film composition are shown in Table 4.
[0102]The 10-nm-thick magnetic film (Co69Cr19Pt12) was formed on each inorganic compound film. The data of 20 Gb(s)/$inch^2$ is written in with the magnetic disk drive using the obtained medium (magnetic disk), and an S/N (dB) ratio when it reads is shown in Table 4.
[0103]
[Table 4]

表 4

NO.	ターゲット組成(wt%)		無機化合物膜粒子中のCoO量(wt%)	無機化合物膜		磁気ディスクS/N(dB)	備考
1	CoO:99.5	Na_2O-SiO_2-CaO系ガラス:0.5	99	粒子:CoO結晶 平均粒子径:17.0nm 標準偏差/平均粒子径X100:29%	粒界:非晶質 粒界幅:<0.1nm	12	比較例
2	CoO:98.5	Na_2O-SiO_2-CaO系ガラス:1.5	98	粒子:CoO結晶 平均粒子径:12.0nm 標準偏差/平均粒子径X100:18.2%	粒界:非晶質 粒界幅:0.1nm	25	-
3	CoO:95	Na_2O-SiO_2-CaO系ガラス:5	94.5	粒子:CoO結晶 平均粒子径:11.2nm 標準偏差/平均粒子径X100:17.5%	粒界:非晶質 粒界幅:0.5nm	32	-
4	CoO:90	Na_2O-SiO_2-CaO系ガラス:10	90	粒子:CoO結晶 平均粒子径:11.0nm 標準偏差/平均粒子径X100:16.1%	粒界:非晶質 粒界幅:0.7nm	35	-
5	CoO:85	Na_2O-SiO_2-CaO系ガラス:15	84.2	粒子:CoO結晶 平均粒子径:10.2nm 標準偏差/平均粒子径X100:15.2%	粒界:非晶質 粒界幅:1.2nm	34	-
6	CoO:70	Na_2O-SiO_2-CaO系ガラス:30	67	粒子:CoO結晶 平均粒子径:7.2nm 標準偏差/平均粒子径X100:14.2%	粒界:非晶質 粒界幅:1.8nm	29	-
7	CoO:65	Na_2O-SiO_2-CaO系ガラス:45	63	粒子:非晶質 平均粒子径:6.0nm 標準偏差/平均粒子径X100:26.3%	粒界:非晶質 粒界幅:2.9nm	11	比較例
8	CoO:95	SiO_2+TiO_2:5	95.1	粒子:CoO結晶 平均粒子径:13.2nm 標準偏差/平均粒子径X100:16.2%	粒界:非晶質 粒界幅:0.7nm	27	-
9	CoO:90	SiO_2+$TiO_2$10	89.6	粒子:CoO結晶 平均粒子径:12.0nm 標準偏差/平均粒子径X100:13.3%	粒界:非晶質 粒界幅:0.9nm	35	-
10	CoO:85	SiO_2+$TiO_2$15	85.3	粒子:CoO結晶 平均粒子径:12.0nm 標準偏差/平均粒子径X100:16.2%	粒界:非晶質 粒界幅:1.1nm	33	-
11	CoO:80	SiO_2+$TiO_2$20	80.1	粒子:CoO結晶 平均粒子径:10.2nm 標準偏差/平均粒子径X100:13.1%	粒界:非晶質 粒界幅:2nm	28	-
12	CoO:65	SiO_2+$TiO_2$45	62.5	粒子:非晶質 平均粒子径:4.2nm 標準偏差/平均粒子径X100:26.3%	粒界:非晶質 粒界幅:2.7nm	14	比較例

[0104]In the magnetic disk of No.1 of Table 4, in the amount of CoO(s) of the particle portion in an inorganic compound film, the width of the grain boundary phase became small at 99wt%, and the particle diameter of the inorganic compound film became large, and standard deviation/mean particle diameter also became large, as a result, the particle diameter of the magnetic film also became large, and S/N fell.
[0105]In the magnetic disk of No.7, the amount of CoO(s) in a film is 63wt% contrary to No.1, The width of the grain boundary phase became large, the particle diameter of the inorganic compound film was extremely small, and since crystallinity also worsened, a magnetic film could not make the particle diameter of the inorganic compound film reflect, but as a result, particle diameter control of the magnetic film became difficult, and the S/N ratio became a low value.
[0106]In the magnetic disk of No.10, the ingredient mixed to CoO is replaced with Na_2O–SiO_2–CaO system glass,

and it is considered as SiO_2+TiO_2. Even if the ingredient mixed to CoO changed, the tendency was almost the same.

[0107]When the range of the amount of CoO(s) of the particle portion in [Table 4 to] an inorganic compound film is 65 - 98wt% (for example, No.2-6 of Table 4, 8-11), a S/N ratio is 25 or more. Therefore, as a target for obtaining the film in the composition range which can obtain such the characteristic, 65 - 98wt% has the desirable amount of CoO(s).

[0108]The width of a grain boundary phase is controllable by the rate in the target of the material used as the grain boundary phase ingredient of an inorganic compound film. By the width of a grain boundary phase being 0.1-2 nm, distance between the magnetic particles of a magnetic film can be made the optimal, and the interaction between the magnetic particles of a magnetic film can be reduced. And the magnetic disk which reduced the flux reversal unit at the time of record or elimination can be obtained by reducing the magnetic interaction between magnetic particles.

[0109]In this example, although CoO, Na_2O-SiO_2-CaO system glass and CoO, and SiO_2+TiO_2 were shown, the oxide which has a crystal structure of a NaCl type or a spinel type instead of CoO may be used. moreover -- as Na_2O-SiO_2-CaO system glass or the thing replaced with SiO_2+TiO_2 -- the [periodic table] -- the same effect is expectable also with I-V fellows' oxide, a nitride, and boride.

[0110]As mentioned above, the substance which constitutes particles and a grain boundary phase, concentration (composition ratio), a membranous stacking tendency, particle diameter, the thickness of a grain boundary phase, distribution of a grain boundary, etc. are controllable by changing selection or the film formation condition of material about each of an inorganic compound film, an interlayer, and a magnetic film. As for the crystal grain child of each film, it is most preferred to carry out crystal orientation so that it may be easy to take consistency of a grating constant mutually.

[0111]Although the glass substrate was used as the substrate 1 in this example, Polymer materials, such as polyethylene, polyester, polyolefine, cellulose, polyvinyl chloride, polyimide, and polycarbonate, Ceramic glass, such as metallic materials, such as aluminum, an aluminum alloy, and a titanium alloy, and alumina glass, or such composites may be used. As shape of a substrate, tape shape, film state, a sheet shaped, card shape, the shape of a drum, etc. may have in addition to discoid.

[0112]There are a recording method within a field which divides roughly and forms recording magnetization in film surface inboard, and a vertical recording system which forms recording magnetization perpendicularly at a film surface in the information storage method of a magnetic recording medium.

[0113]The Co alloy of hexagonal close-packed structure, etc. are used for the magnetic layer of the recording medium within a field. Since a Co alloy film has the uniaxial anisotropy which uses c axis as an easy axis, it carries out orientation of the c axis into a film surface.

[0114]The Co alloy of hexagonal close-packed structure, etc. are used also for a vertical recording medium. In this case, orientation of the c axis is carried out at right angles to a film surface. The stacking tendency of a magnetic film is controllable also by formation of the interlayer formed between an inorganic compound film or an inorganic compound film, and a magnetic film. Therefore, this invention can be used for both the recording method within a field, and a vertical recording system.

[0115]

[Effect of the Invention]According to this invention, the crystal grain child of a magnetic film is detailed, becomes uniform particle sizes, and can perform high density recording.

[Translation done.]